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INTEGRATING BIOLOGICAL PRINCIPLES WITH INSTRUCTION IN VOCATIONAL AGRICULTURE, A RESEARCH REPORT OF A GRADUATE STUDY. RESEARCH SERIES IN AGRICULTURAL EDUCATION.

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TO DETERMINE THE FEASIBILITY OF INTEGRATING BIOLOGICAL PRINCIPLES WITH INSTRUCTION IN VOCATIONAL AGRICULTURE IN OHIO HIGH SCHOOLS, 15 PILOT SCHOOLS AND 8 CONTROL SCHOOLS WERE STUDIED. PRETESTS ADMINISTERED TO STUDENTS IN OCTOBER 1963 WERE AN AGRICULTURAL ACHIEVEMENT TEST, A BIOLOGICAL PRINCIPLES TEST, THE CALIFORNIA SHORT-FORM TEST OF MENTAL MATURITY, AND THE EDUCATIONAL INTEREST INVENTORY. POSTTESTING IN MAY 1964 INCLUDED ALL EXCEPT THE CALIFORNIA SHORT-FORM. A QUESTIONNAIRE ADMINISTERED TO AGRICULTURE TEACHERS IN THE PILOT SCHOOLS REVEALED EIGHT ADVANTAGES, INCLUDING--(1) THE PROGRAM WAS MORE CHALLENGING AND INTERESTING TO STUDENTS, AND (2) IT CAUSED THE TEACHER TO PREPARE BETTER. ONE OF THE FOUR DISADVANTAGES WAS THAT MORE TIME WAS NECESSARY TO TEACH BIOLOGICAL PRINCIPLES, AND OTHER UNITS HAD TO BE DROPPED. INTERPRETATION OF THE TEST DATA WAS THE BASIS FOR EIGHT CONCLUSIONS, INCLUDING--(1) THE NUMBER OF PRINCIPLES TAUGHT WAS THE MOST SIGNIFICANT FACTOR INFLUENCING ACHIEVEMENT IN BIOLOGY, (2) DIFFERENCE IN STUDENT ACHIEVEMENT BETWEEN 1ST- AND 2ND-YEAR PILOT SCHOOLS WAS NOT CONSISTENT ON ALL TESTS, AND (3) FRESHMAN AND SOPHOMORE STUDENTS SHOWED GREATER ACHIEVEMENT THAN JUNIOR AND SENIOR STUDENTS WHEN THE BIOLOGICAL PRINCIPLES APPROACH WAS USED. (EM)

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A Research Report
# of a
Graduate Study

Issued by
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College of Agriculture and Home Economics
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INTEGRATING BIOLOGICAL PRINCIPLES WITH INSTRUCTION IN VOCATIONAL AGRICULTURE

By

John T. Starling and Ralph E. Bender

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FOREWORD

Agriculture, like the rest of the economy, is undergoing rapid and accelerating changes due to technological and scientific developments and improved methods of organization and management.

It is evident that increased impetus will be given to science in the years ahead and instruction in vocational agriculture should become more science-oriented to keep pace with the scientific and technological developments in agricultural production.

Since many agricultural problems lend themselves to an application of biological principles, this study should provide direction for improving instruction in vocational agriculture and provide a means for a better understanding of biological principles basic to agriculture through an inductive method of teaching.

A forerunner to this study was conducted at the University of California, Davis, with Sidney S. Sutherland, Professor of Agricultural Education, University of California, and W. Earl Sams, Consultant, Bureau of Secondary Education, State Department of Education, serving as co-ordinators of the project.

TABLE OF CONTENTS

Page

INTEGRATING BIOLOGICAL PRINCIPLES WITH INSTRUCTION IN VOCATIONAL AGRICULTURE

CONCLUSIONS 1

Need for the Study. 2
Purpose of the Study 6
Specific Objectives 6

PROCEDURES EMPLOYED IN THE STUDY

Selecting the Pilot and Control Schools 8
Developing and Selecting Evaluative Tests 9
Developing and Administering the Questionnaire. . . . 10

STATISTICAL ANALYSIS OF TEST RESULTS

Selection and Use of Statistical Models 11

MAJOR FINDINGS

Significance of Difference in Change in Student Achievement Between the Pilot and Control Schools 16
Significance of Difference in Change in Student Achievement in Agriculture, Biology, and Agriculture and Science Interest Between Ninth Grade Students in First-Year Pilot Schools and Second-Year Pilot Schools. 18
Significance of Difference in Change in Achievement in Agriculture, Biology, and Agriculture and Science Interest Between Tenth Grade Students in First-Year Pilot Schools and Second-Year Pilot Schools. 20
Correlation Between Independent Variables and Change in Achievement in Agriculture and Biology. 22
Significance of the Independent Variables in Predicting the Dependent Variables Change in Achievement in Agriculture and Biology. 25

TEACHER'S EVALUATION OF THE BIOLOGICAL PRINCIPLES APPROACH

Summary of Principles Taught 27
Reasons for Not Teaching Other Principles. 29

CONTENTS (Continued)

Page

Extent to Which Students Were Able to Transfer Their Understanding of the Principles to the Study of Other Agricultural Problems. 29
Ways in Which the Biological Principles Approach Added to the Effectiveness of Teaching 31
Teachers' Opinions as to the Major Advantages and Disadvantages of the Biological Principles Approach. 32

APPENDIXES

Appendix A - Agricultural Achievement Test 35
Appendix B - Biological Science Agriculture Test . . 52

BIBLIOGRAPHY 67

INTEGRATING BIOLOGICAL PRINCIPLES WITH INSTRUCTION IN VOCATIONAL AGRICULTURE

CONCLUSIONS

Based on an interpretation of the data presented in this study, the following conclusions were drawn:

1. When biological principles are integrated into the teaching of vocational agriculture, at the high school level, the students show greater achievement in agriculture and have a greater understanding of biological principles. The students are also more interested in agriculture and in science.
2. The teaching of biological principles integrated with instruction in vocational agriculture is desirable in Ohio high school vocational agriculture classes.
3. The difference in student achievement between first and second year pilot schools was not consistent on all tests.
4. Freshman and sophomore students showed greater achievement than junior and senior students when the biological principles approach was used in teaching vocational agriculture.
5. The number of principles taught was the most significant factor influencing achievement in biology.

6. Teachers believed that, when the biological principles approach was used in teaching high school students of vocational agriculture, their students were able to transfer their understanding of principles in the solving of other agricultural problems.
7. Classroom teaching which involved integrating biological principles with instruction in vocational agriculture required more teacher time but caused teachers to do a more thorough job of planning for their classes.
8. Teachers believed that in-service education programs should place more emphasis on the development of related teaching aids and demonstrations in order to improve the teaching of biological principles.

Need for the study

Teachers of vocational agriculture have become concerned about the explosion of knowledge and the rapid technological developments, and they realize the need to search for ways to adjust their programs to keep pace with the changing times. This need is also emphasized by the following statement:

> Little change has been made in vocational agriculture education since its inception. The content of the courses in vocational agriculture as well as its place in the curriculum need re-examination. Educational leaders need to determine the proper emphasis to be given in courses in order to broadly educate young people who, to the limit of their respective abilities, can adjust to changing times.[1]

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[1] Mervin G. Smith, Carlton F. Christian, Adjustments in Agriculture-A National Basebook (Iowa State University Press, Ames, Iowa, 1963), p. 366.

If we lean heavily toward applied training, the student may be better prepared for his first job. On the other hand, applied training, may become out of date by the time the student has been on the job for a short while. In the long run, a basic understanding of principles may serve him better than simply knowledge of how to do things.

The "principle approach" lends itself to instruction which is directed toward the development of understanding and the ability to make appropriate application to a wide range of agricultural problems. It has long been accepted that principles should be taught with application and that the most effective teaching results when principles and application are presented in the closest association with each other.

John M. Mason said,

> The aim of education should be to convert the mind into a living fountain and not a reservoir. That which is filled by merely pumping in will be emptied by pumping out.[2]

Recent studies have shown that there will be a decreasing number of opportunities for vocational agriculture graduates to enter farming in the future--thus, making it necessary for them to find employment in jobs related to agriculture.

With the rapid changes in technology, it is anticipated that the educational competencies for these jobs will change many times in the next few years. This is substantiated by the following quotation:

> Since jobs will change materially during the working lives of many in the future, a reassessment of our vocational education should be made by the

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[2] *Ibid.*, p. 359.

> states and the federal government. With the changing careers we contemplate, rigid vocational training seems to be of doubtful value.[3]

As better means of transportation are developed and we move toward more unified international educational programs, it is reasonable to assume that more people will find employment in foreign countries. The skills and abilities needed for these jobs would most likely be much different than those needed for the jobs in the community in which the individual was trained.

Technological developments are needed and taking place in other countries as is indicated by the following quotation taken from Phi Delta Kappan Magazine:

> Agriculture has been traditionally regarded as the occupation of the shoeless, a concept with roots in the early colonization period. A few landlords were masters of land and life over a great portion of the population. The "peon-patron" relation which evolved still prevails in most countries. It is a cultural heredity likely to survive for many years.
>
> Inevitably, this condition affects concepts of agricultural education. For years, it was believed that no training is needed by those who till the soil and take care of animals. Such tasks had been performed throughout the ages by the less educated or non-educated. Fortunately, this concept is changing, even though slowly. The main impetus for this change comes from technological advances.[4]

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[3] Goals for Americans, The Report of the President's Commission on National Goals (Prentice Hall, Inc., 1960), p. 202.

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[4] Fernando Del Rio, "Agricultural Education in Latin America and Its Promise for the Future," Phi Delta Kappan Magazine, Volume XLV, Number 4, January 1964, p. 202.

The need to keep pace with technological developments is not confined only to agricultural education but to all phases of education. In addition to the many technological developments, socio-economic changes have caused educators to focus attention on broadening all educational programs. Studies have shown that one out of every five persons move each year and consequently a person educated in New York may find employment in California, or vice versa. The constant increase in automation eliminates some jobs while creating others and the competencies needed for these jobs are continually changing.

In a national seminar held at The Ohio State University, Benjamin C. Willis, Superintendent of Schools in Chicago, said:

> We must not only broaden our educational spectrum and expand it, but also build more flexibility into it and make our judgments of its effectiveness more individualized and varied. Broad principles must form the foundation for any educational program. It is futile to prepare individuals for specific kinds of work which may or may not exist tomorrow without providing them with the general skills that will permit them to modify specific capabilities as the need arises.[5]

With the complexity of our American society, we are challenged to search for new and better methods of teaching. Much research is being conducted in the field of education as is emphasized by the following statement:

> One need but glance at a recent volume of the "Encyclopedia of Educational Research" to become impressed with the great body of knowledge about education and the educative process that is accumulating year by year.[6]

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[5] Benjamin C. Willis, A Design for the Future, Report of a National Seminar on Agricultural Education, The Ohio State University, 1963, p. 75.

[6] Roald F. Campbell, John E. Corbally, John A. Ramseyer, Introduction to Educational Administration (Allyn and Bacon, Inc., Boston, 1962), p. 50.

The writer is of the opinion that teachers of vocational agriculture have an excellent opportunity to teach scientific principles and help students see the practical application of these principles, thus making science courses more meaningful to students. With the increased emphasis placed on science some educators have expressed the opinion that the emphasis has been placed on science as a course without giving students an opportunity to see its relationship to other fields of knowledge. This thought is expressed in the following statement:

> We have so exalted the power of science that we sometimes forget its relation to other fields of knowledge.[7]

Since we have this opportunity in vocational agriculture we need to conduct research to determine the feasibility of this approach and to determine the best methods to use.

Purpose of the study

The purpose of this study was to determine the feasibility of integrating biological principles with instruction in vocational agriculture at the high school level in Ohio.

Specific objectives

The major purpose of the study was--

1. To determine the significant difference between the pilot and control schools relative to changes in achievement in agriculture, biology, and interest in agriculture and science.

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[7] Edgar Dale, Audio-Visual Methods in Teaching (The Dryden Press, New York, 1954), p. 142.

2. To determine the significant difference between pilot schools that are first year participants and those that are second year participants relative to changes in achievement in agriculture, biology, and interest in agriculture and science.

3. To determine the correlation between the dependent variables change in achievement in agriculture and biology and the following independent variables:

   a. Year in the project.

   b. Number of principles taught.

   c. Age of the student.

   d. Status in biology.

   e. California Mental Maturity score.

   f. Agricultural interest score.

   g. Science interest score.

4. To determine which independent variables are most important in influencing the dependent variables.

5. To determine the desirability of integrating the biological principles with instruction in vocational agriculture in Ohio.

6. To determine the changes needed to make the biological principles approach more effective.

PROCEDURES EMPLOYED IN THE STUDY

In order to accomplish the objective evaluation in this study, the design involved pilot and control schools. Both groups were given a pre-test and a post-test. This study was patterned after a similar study conducted in California. However, this study went beyond the California study in that an Agricultural Achievement test and an Interest Inventory test were given in addition to the California Mental Maturity test and a Biological Principles test used in the California study. This study also made use of a more comprehensive statistical analysis.

The subjective evaluation was accomplished through the use of a questionnaire to secure opinions from the teachers of vocational agriculture in the pilot schools.

The major steps in the procedure employed in this study included (1) selecting the pilot and control schools, (2) developing and selecting evaluative tests, (3) administering evaluative tests, (4) developing and administering the questionnaire, and (5) summary and analysis of data.

Selecting the pilot and control schools

In selecting the pilot schools, assistant state supervisors of vocational agriculture were asked to recommend schools that, in their opinion, would give the biological principles approach a fair trial. The supervisors considered such factors as: geographic location, size of school, administrator attitude and teacher competency. From the list of eighteen schools recommended by the supervisors, fifteen agreed to serve as pilot centers in which the teachers would integrate the biological principles into their course of study for high school students of vocational agriculture.

In order to have a benchmark to use in evaluating the biological principles approach, control schools were selected to serve as a means of comparison. The vocational agriculture staff decided that the control schools should be selected from the cooperating schools or schools used for the purpose of training teachers of vocational agriculture. Eight schools were selected for the control group in which a traditional program would be conducted. They were asked to participate only in the testing phase of the program with no attempt to integrate the principles into their course of study.

Developing and selecting evaluative tests

In developing the agricultural achievement test, a list of one hundred and fifty multiple choice questions, based on the major areas of emphasis in the Ohio vocational agriculture program, was developed. This list of questions was rated by the vocational agriculture staff and one hundred questions were selected to make up the agricultural achievement test used in this study.

The biological principles test previously used in the California study was used as the instrument to evaluate understanding of biological principles. This test consisted of seventy-five multiple choice questions.

In the selection of the I.Q. and Interest Inventory tests to be used, the Division of Guidance and Testing, Ohio State Department of

Education was consulted. As a result of their recommendation, the California Short-Form Test of Mental Maturity and Educational Interest Inventory by James E. Oliver were the tests selected.

The pre-tests which included the agricultural achievement, biological achievement, California Mental Maturity, and Interest Inventory were administered the first week in October, 1963.

The post-tests were administered the first week in May, 1964. The California Mental Maturity was not included in the post-tests because the I.Q. scores were obtained from the pre-test.

Developing and administering the questionnaire

The questionnaire used to secure the subjective evaluation was developed by the writer of this study. A list of questions to secure teachers' opinions relative to their experience with the biological principles approach and implications for future programs was developed and submitted to the writer's graduate committee. Their suggestions were incorporated into the development of the questionnaire into its final form. The questionnaire was administered to the teachers in the pilot schools at a meeting with these teachers the second week of May, 1964.

STATISTICAL ANALYSIS OF TEST RESULTS

Selection and use of statistical models

In order to select appropriate statistical models for this study, the writer consulted Professor D. Ransom Whitney, Director of the Statistical Laboratory, Department of Mathematics, The Ohio State University.

Since one of the major objectives of this study was to determine the significance of the difference in change in achievement between the pilot and control schools, the "t" test of significance was selected, as being the most appropriate. Support for this test is given in the following statement:

> The most widely used acceptable test is to compute for each group pre-test - post-test gain scores and to compute a "t" between experimental and control groups on these gain scores.[8]

The "t" test was employed to determine the significance of the difference in changes in scores between the pilot and control schools on the following tests:

1. Agricultural Achievement
2. Biology Achievement
3. Agricultural Interest
4. Science Interest

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[8] Donald T. Campbell, Julian C. Stanley, *Handbook of Research on Teaching*, American Educational Research Association (Chicago, Rand McNally and Company, 1963), p. 217.

The following is a model for this statistic:

$$\frac{\bar{X} - \bar{Y}}{\sqrt{\frac{s_X^2}{n} + \frac{s_Y^2}{m}}}$$

Using Agricultural Achievement as an example, $\bar{X}$ is the mean of the differences, post-test minus pre-test for the control schools, and $\bar{Y}$ is similarly the mean of the same differences for the pilot schools. s_X^2 and s_Y^2 are estimates of the variance of these differences for control and pilot groups. When using the student "t", the researcher tests the hypothesis that an increase on the Agricultural Achievement test for the control group is statistically equal to that of the pilot group. A larger value of "t" rejects this hypothesis at either the 5% or 1% level of significance, and if the hypothesis is rejected, the alternative to be accepted is that the group with the largest mean difference made the most improvement from pre-test to post-test.

The "t" test was also employed to determine the significance of the difference in achievement between ninth and tenth grade students in pilot schools participating in the project the first year and ninth and tenth grade students in pilot schools that were second-year participants.

Another objective of this study was to determine the relationship between the dependent variables, achievement in agriculture and biology and the following list of independent variables:

Mental maturity score

Number of principles taught

Grade level of the student

Age of the student

Agriculture interest score

Science interest score

The statistic employed for this analysis was the correlation coefficient "r". "The correlation coefficient (r), commonly referred to as the product-moment correlation, provides a quantitive measure of relationship between two variables X and Y."[9]

"This statistical model not only provides a measure of strength but also the direction of association, expressed either as positive or negative."[10]

In calculating the correlation between the independent variables and the dependent variables, change in achievement in agriculture and biology, each independent variable was considered separately with the other independent variable held constant.

After determining the correlation between the dependent and independent variables through an analysis of the results of this study, it was still believed that some of the independent variables were more important than others in determining the dependent variables, change in achievement in agriculture, and change in achievement in biology.

The following independent variables were considered:

1. Year in the project.
2. Number of principles taught.

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[9] Henry E. Garrett, Elementary Statistics (New York: David McKay Company, Inc., 1962), p. 92.

[10] Sanford M. Dornbusch and Calvin F. Schmid, A Primer of Social Statistics (New York: McGraw-Hill Company, Inc., 1955), p. 195.

3. Age of the student.
4. Year in high school.
5. Status in biology
   (a) had biology in a previous year
   (b) taking biology concurrently
   (c) has not had biology
6. California Mental Maturity Score (pre-test).
7. Agricultural Interest Score (pre-test).
8. Science Interest Score (pre-test).

In order to determine the most important variables, the analysis of covariance "F" test was applied to the data. The following is a model of this statistic:

$$Y = b_0 + b_1 X_1 + b_2 x_2 + b_3 X_3 + b_4 X_4 + \begin{array}{l} \text{a1 Biology Previously} \\ \text{a2 Biology Concurrently} \\ \text{a3 No Biology} \end{array}$$

$$+ b_6 X_6 + b_7 X_7 + b_8 X_8$$

In one problem Y is change in achievement in agriculture, and in the other, change in achievement in biology and $X_1 - X_8$ corresponds to independent variables 1 to 8. The a_1, a_2, a_3 are effects due to status in biology and the b's are regression coefficients which are estimated.

The measure of central tendency selected was the mean because "The arithmetic mean is the most widely used measure of central value."[11]

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[11] *Ibid.*, p. 62.

MAJOR FINDINGS

Table 1 shows that the students in the pilot schools showed greater achievement between the pre- and post-test than the students in the control schools. The greatest difference was in biology achievement where the students in the pilot schools showed a net gain of 5.23 whereas the students in the control schools showed a net gain of only 1.44.

Table 1 shows a decrease in agriculture interest for students in both the pilot and control schools; however, the students in the pilot schools showed less decrease than those in the control schools.

It is quite significant to note that the students in both the pilot and control groups had almost the same mental maturity score with a mean score of 98.68 for students in the pilot schools and 98.87 for students in the control schools. The two groups were so near the same that one could say there was no difference so far as mental ability was concerned.

Table 1.--Mean scores on pre- and post-agriculture, biology, agriculture interest, science interest and California Mental Maturity tests for pilot and control schools

	Pilot			Control		
Test	Pre	Post	Net Gain or Loss	Pre	Post	Net Gain or Loss
Agriculture Achievement	43.47	47.36	3.89	47.60	49.76	2.16
Biology Achievement	25.76	30.97	5.23	28.59	30.03	1.44
Agriculture Interest	13.02	12.92	-.10	13.33	12.69	-.64
Science Interest	10.88	11.08	.20	11.12	10.87	-.25
California Mental Maturity	98.68			98.87		

Significance of difference in change in student achievement between the pilot and control schools

Even though the foregoing table shows a greater increase in change in achievement for the pilot schools over the control schools, it might appear that this increase was not significant. When the "t" test was applied to the data the increase for the pilot over the control schools on all tests was significant at either the .01 or .05 level of confidence.

Table 2 shows the mean difference in agriculture achievement between the pre- and post-test for the pilot schools to be 3.891 while the mean difference for the control schools was 2.162. This was significant at the .05 level of confidence as is shown by the "t" value of 2.455.

The mean difference in achievement in biology between the pre- and post-test for the pilot schools was 5.211, while this difference was only 1.443 for the control schools. This was quite significant as can be seen by referring to Table 2. This table shows a "t" value of 6.630 which is significant at the .01 level. The writer was of the opinion that this analysis was highly important because it showed that the students who were taught the biological principles showed greater achievement in biology than those who were not taught the principles.

As it is shown in Table 2, there was a decrease in interest in agriculture between the pre- and post-test in both the pilot and control schools; however, the decrease was less for the pilot schools than for the control schools. There was a significant difference between the pilot and control schools. This difference was significant at the .05 level in favor of the pilot schools based on a "t" value of 2.416.

Table 2 also shows there was an increase of .200 in science interest between the pre- and post-test in the pilot schools while the control schools showed a decrease of .245. This difference in science interest was significant at the .01 level of confidence.

The implication can be made that students of vocational agriculture who have biological principles integrated into their course of study show greater achievement in agriculture and biology and are more interested in agriculture and science.

Table 2.--Mean difference between pre- and post-test achievement in agriculture, biology, agriculture interest, and science interest for pilot and control schools

Test	Pilot n = 422 Mean Difference	Control n = 235 Mean Difference	t Value
Agriculture Achievement	3.891	2.162	2.455[b]
Biology Achievement	5.211	1.443	6.630[a]
Agriculture Interest	-.102	-.643	2.416[b]
Science Interest	.200	-.245	3.403[a]

a = Significant at .01 level
b = Significant at .05 level

Significance of difference in change in student achievement in agriculture, biology, and agriculture and science interest between ninth grade students in first-year pilot schools and second-year pilot schools

Seven of the fifteen pilot schools used in this study were participating in this project the second year. Some might conclude that a year of previous experience might cause them to do better than the first-year schools. Others might conclude that the first-year schools would do better because of the "Hawthorne Effect."

Table 3 shows that there was a significant difference at the .05 level of confidence in difference in change in achievement in agriculture between ninth grade students in pilot schools participating in the project the first year, and ninth grade students in pilot schools participating in the project the second year. The mean difference for the students in the second-year pilot schools was 6.208 while the mean difference for the students in the first-year pilot schools was only 3.066.

There was also a significant difference at the .05 level of confidence in difference in science interest between ninth grade students in first-year pilot schools and ninth grade students in second-year pilot schools. The mean difference between the pre- and post-test for the first-year students was .039 while the mean difference for the second-year students was .794.

There was no significant difference between the first and second-year schools in difference in change in achievement in biology and agriculture interest.

Table 3.--Mean difference between pre- and post-test achievement in agriculture, biology, agriculture interest, and science interest for ninth grade students in first-year pilot schools and second-year pilot schools

Test	1st year n = 61 Mean Difference	2nd year n = 101 Mean Difference	t Value
Agriculture Achievement	3.066	6.208	2.059[b]
Biology Achievement	5.132	5.089	.033
Agriculture Interest	-.016	.455	.936
Science Interest	.039	.794	2.590[b]

b = .05 level of significance

Significance of difference in change in achievement in agriculture, biology, and agriculture and science interest between tenth grade students in first-year pilot schools and second-year pilot schools

There were seventy tenth grade students in the first-year pilot schools and one hundred and seven tenth grade students in the second-year pilot schools. Even though seven of the fifteen pilot schools were participating in this project, the second year, all students were first-year participants so the only difference would be in the experience of the teacher. The mean difference for both groups and the "t" values is presented in Table 4.

Table 4 shows a significant difference at the .05 level in mean difference in change in achievement in biology between tenth grade students in first-year pilot schools and tenth grade pilot schools.

This difference was in favor of the first-year schools. The mean differences in agriculture interest was -1.128 for the tenth grade students in the first-year pilot schools and -.141 for tenth grade students in the second-year pilot schools. This was a significant difference at the .05 confidence level in favor of the second-year pilot schools.

The most significant was the difference in interest in biology between the first- and second-year pilot schools. The tenth grade students in the first-year pilot schools showed a decrease of -.364 interest in science while the students in the second-year pilot schools showed an increase of .238. The calculated "t" value for this difference was 2.988, making a significant difference at the .01 level of confidence.

A comparison of Tables 3 and 4 shows that the only test on which there was consistency between first- and second-year students was science interest. Due to this inconsistency, the writer was of the opinion that it would be difficult to say that there was a significant advantage to the year of experience.

Table 4.--Mean difference between pre- and post-test achievement in agriculture, biology, agriculture interest, and science interest for tenth grade students in first-year pilot schools and second-year pilot schools

Test	1st year n = 70 Mean Difference	2nd year n = 107 Mean Difference	t Value
Agriculture Achievement	4.486	3.365	-.837
Biology Achievement	8.714	5.860	-2.219[b]
Agriculture Interest	-1.128	-.141	2.414[b]
Science Interest	-.364	.238	2.988[a]

a = Significant at .01 level
b = Significant at .05 level

Correlation between independent variables and change in achievement in agriculture and biology

In discussing the design for this study, the question as to what would be the relationship between certain independent variables and change in achievement in agriculture and biology was often presented. The independent variables frequently suggested were:

Mental Maturity Score

Number of Principles Taught

Student Age

Grade Level of Students

Biology Status

Agriculture Interest

Science Interest

After the data were analyzed by the correlation coefficient (r), it was still difficult to determine which correlations were significant. In order to determine the significance of the various correlations, reference was made to Snedecer, Statistical Models, and the following formula was applied:[12]

$$t = r\sqrt{\frac{n - 2}{1 - r^2}}$$

Using this formula, it was determined that an "r" value equal to or greater than .0955 was significant at the .05 confidence level and an "r" value equal to or greater than .1253 was significant at the .01 confidence level.

Table 5 shows the correlation between student age and change in achievement in agriculture to be significant at the .05 level of confidence. The older students showed slightly greater achievement in agriculture between the pre- and post-tests than younger students.

The opposite was the case between student age and change in achievement in biology in that the older students showed less change in achievement in biology between the pre- and post-test than the younger students. This negative correlation was significant at the .01 level of confidence.

There was also negative correlation which was significant at the .01 confidence level between grade level and change in achievement in biology. The students in the upper high school grades showed less change in achievement in biology between pre- and post-test than students in the lower high school grades.

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[12] George W. Snedecer, Statistical Methods (Ames, Iowa: Iowa College Press, 1948), p. 149.

There was no significant correlation between the other independent variables and change in achievement in agriculture or biology.

Based on the results of this study, it appears that younger students achieve more than older students. Perhaps it could be implied that younger students try harder or that the biological principles approach is more adapted for younger students.

Table 5.--Correlation between independent variables and change in achievement in agriculture and biology

Independent Variable	Change in Achievement in Agriculture r value	Change in Achievement in Biology r value
Mental Maturity Score	-.0277	.0565
Number of Principles Taught (Pilot schools only)	.0497	.0347
Grade Level of Students	-.0269	-.1538[a]
Age of Student	.1100[b]	-.2289[a]
Agriculture Interest Score (Pre-test)	.0497	.0613
Science Interest Score (Pre-test)	.0109	.0791

a = Significant at .01 level
b = Significant at .05 level

Significance of the independent variables in predicting the dependent variables change in achievement in agriculture and biology

Since there was little correlation between the independent and dependent variables it seemed advisable to further analyze the data to determine which independent variables were the best predictors of the dependent variables change in achievement in agriculture and biology. The "F" test was the statistic employed for this purpose.

After the "F" test was used to analyze the data, it was apparent that there was no significance between any of the independent variables and change in achievement in agriculture so these results are not presented in the following table. The results relative to achievement in biology are presented in Table 6.

Table 6 shows that the two variables most significant in predicting change in achievement in biology were the number of principles taught and biology status. These factors were significant at the .01 confidence level. It should also be noted that students who were taking biology concurrently achieved the best while the students having had biology previously achieved the least and the students who had not had biology were in between. The age of students was significant at the .01 level; however, this was of negative value as can be seen by the "F" value of -15.547 in Table 6.

Based on the analysis presented in this table, if a study similar to this was conducted the two most reliable factors in predicting achievement in biology would be the number of principles taught and status in biology.

Table 6.--Significance of independent variables in determining the dependent variable, change in achievement in biology

	Achievement in Biology	
Variable	Regression Coefficient	F Value
Year in project	.032	.0019
Number of principles taught	.265	7.78[a]
Student age	.864	-15.547[a]
Year in high school	.616	2.47
Biology status	-2.363[b] 2.040[c] .323[d]	9.831[a]
California Mental Maturity	.013	.542
Agriculture Interest	.029	.0756
Science Interest	.247	2.396

a = Significant at .01 level
b = Student had biology a previous year
c = Student taking biology concurrently
d = Student has not had biology

The writer is of the opinion that the best predictor is the number of principles taught. This is particularly true since it would be difficult to have all students taking biology concurrently with the biological principles approach in vocational agriculture. The writer would recommend that, if a similar study was conducted, a greater effort should be made to teach more of the principles.

TEACHER'S EVALUATION OF THE BIOLOGICAL PRINCIPLES APPROACH

The teacher's evaluation of the biological principles approach was secured through the use of a three-page evaluation instrument. A meeting of all the teachers in the pilot schools was held the second week in May, 1964, at which time the teachers reacted to all items on the evaluation instrument. In the cases of multiple teacher departments, the two teachers conferred with each other in answering questions and only one evaluation per school was obtained. The experience of the teachers in the fifteen pilot schools placed them in an excellent position to express their opinion on the questions on the evaluation instrument. This subjective analysis provides a valuable addition to the objective analysis included in the previous chapter of this study.

Summary of principles taught

At the outset of this study, the writer was hopeful that an average of ten of the twenty-two biological principles per school would be taught. Actually, the average number of principles taught per school was 7.1.

Table 7.--Number of schools teaching each principle and number of schools teaching each principle inductively

Principle	Number of Schools Teaching This Principle	Number of Schools Teaching This Principle Inductively
Reproduction	15	15
Photosynthesis	14	12
Plant nutrition	14	14
Animal nutrition	13	13
Germination of seeds	12	11
Transpiration	9	8
Genetics	8	8
Growth	8	7
Diffusion	7	6
Matter and energy	7	4
Respiration	7	7
Living matter	6	5
Regulators of plant growth	6	5
Movement of substances in living organisms	5	4
Ecology	4	4
Non-living matter	4	3
Pathology	4	2
Classification	3	2
Organic cycles	3	2
Nervous system	3	3
Endoctrine system	2	2
Irritability	1	0

Table 7 is a summary of the number of schools teaching each of the twenty-two principles and the number of schools teaching each of the principles inductively, or incorporating them into the solving of an agricultural problem. "Reproduction" was taught by all fifteen of the pilot schools while "Irritability" was taught by only one school. A comparison of Columns 2 and 3 in Table 7 shows there was close correlation between the schools teaching a principle and the schools teaching a principle inductively.

The principles of reproduction, photosynthesis, plant nutrition, animal nutrition, germination of seeds, transpiration, genetics, and growth were taught by more than 50 per cent of the schools. Table 7 also shows that the principles of diffusion, matter and energy, respiration, living matter, regulators of plant growth, and movement of substances in living organisms were taught by more than 30 per cent of the schools. The remaining eight principles were taught by less than 30 per cent of the schools.

Reasons for not teaching other principles

In answer to this question, all fifteen teachers gave "a lack of time to prepare" as their reason for not teaching some of the principles. Nine of the fifteen teachers said, "the principles didn't fit into my course of study" or "they didn't apply to the subject areas I was teaching." One teacher stated, "My students were too slow to comprehend some of the principles," and one teacher stated, "I could teach all of the principles if they were spread out over a four-year period."

The writer would doubt the validity of the reason, "My students were too slow to comprehend some of the principles," because in the statistical analysis of this study it was shown that there was no correlation between student I.Q. and change in achievement in agriculture and biology.

Extent to which students were able to transfer their understanding of the principles to the study of other agricultural problems

A four-point rating scale was used to secure teachers' opinions as to the extent of transfer of understanding. The teachers checked "very well," "some," "very little," or "none."

Twelve of the fifteen teachers checked "some" as to the extent to which students were able to transfer their understanding of the principles in the study of other agricultural problems while the other three checked "very well."

The teachers gave some specific examples of transfer of understanding of the principles which were as follows:

1. "When students understood the principles of reproduction relative to one species of farm animals, they were able to transfer this understanding to other species."
2. "Students were able to see the reason for careful selection of livestock when they understood the principle of genetics."
3. "Students were able to associate the principle of photosynthesis with the rate of planting corn."
4. "In studying plant nutrition, students could see that the principle of nutrition was dependent on other principles such as: photosynthesis, transpiration and diffusion."
5. "When we were discussing chemical weed control, the students associated regulators of plant growth as interferring with the growth process."
6. "In studying animal nutrition, students had a better understanding of the interdependence of plants and animals since we had previously studied photosynthesis and plant nutrition."
7. "Students could associate the principle of ecology with environment control in swine."

8. "The placement of fertilizer on corn made sense to students when they understood the principles of diffusion and plant nutrition."

In meetings with the teachers, emphasis was given to having the students state a principle after a problem was taught which included the application of a principle. Emphasis was also given to providing an opportunity for students to apply principles previously learned in solving other agricultural problems.

Ways in which the biological principles approach added to the effectiveness of teaching

The teachers were in general agreement that the biological principles approach added greatly to the effectiveness of their teaching. Six of the teachers reported, "It caused me to study and do a more thorough job of preparing for my classes." Five teachers reported, "This approach makes the vocational agriculture program more applicable to non-farm students" or "It provides students with a better background for non-farm agricultural jobs." Four teachers reported, "It has stimulated more thinking and interest among students" and two teachers stated, "This approach has increased my interest in teaching." Two teachers stated, "This approach helps to gain respect for vocational agriculture" and one teacher reported, "It coordinates agriculture with science courses and makes the total school program more meaningful to students."

All teachers expressed the opinion that the biological principles approach should be extended to more schools in order to upgrade the teaching in vocational agriculture.

It is the opinion of the writer that all good teachers spend more time in preparing to teach a class than in actually teaching the class. If the biological principles approach caused teachers to do a more thorough job of planning, it was worthwhile.

Teachers' opinions as to the major advantages and disadvantages of the biological principles approach

Advantages -

1. Principles don't become obsolete like production practices.
2. The principles approach emphasizes why rather than so much how.
3. This approach makes agriculture more scientific which appeals to better students.
4. This scientific approach is more effective in preparing students for college.
5. Better understanding is developed when principles are emphasized in the teaching.
6. The vocational agriculture program was more challenging and the students were more interested.
7. This approach removes the idea that agriculture isn't scientific.
8. It causes the teacher to do a better job of preparation.

Disadvantages -

1. The slower students tend to get lost with this scientific approach.

2. A lot more time is required for preparation.
3. Many of the references required are not written on high school level.
4. In order to develop understanding of a principle, more time was required which made it necessary to eliminate some units from the course of study.

It is the opinion of the writer that S. S. Sutherland gives an excellent summary of the advantages and disadvantages of the inductive method of teaching biological principles in the following statements taken from Agricultural Education Magazine:

> Teaching inductively has much to recommend it. True, it takes more time to cover a given subject; more teacher preparation is involved to set up the necessary problems, demonstrations, field trips, etc., but there are compensations which offset these disadvantages.
>
> 1. Discovery is an inherently interesting process and the inductive approach is the discovery approach.
>
> 2. Teachers using it may tend to cover fewer subjects and to teach them more thoroughly.
>
> 3. Centering teaching around broad principles which have wide application should result in students emerging with greater understanding of the practices which are based upon these generalizations.
>
> 4. Since the inductive process students are taught to think; given practice in thinking, especially if deduction is added to induction, and if students are required to apply what they have discovered.
>
> 5. Science teachers are being taught to use this improved teaching procedure. We can hardly afford to drop behind the parage.[13]

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[13] S. S. Sutherland, More Inductive Teaching Needed, Agricultural Education Magazine, Vol. 37, No. 3, September, 1964, p. 71.

APPENDIXES

Appendix A - Agricultural Achievement Test

Appendix B - Biological Science Agriculture Test

APPENDIX A

Department of Agricultural Education
The Ohio State University
and
Vocational Agriculture Service
State Department of Education

AGRICULTURAL ACHIEVEMENT TEST

Name______________________________________ Year in Vo-Ag_____

Name of School______________________________ Year in H. S._____

INSTRUCTIONS

Each test item includes a statement followed by several alternative answers labeled A, B, C, D. Select the answer which best completes the statement. Place the identifying letter in the blank in front of the item number.

Example: In the following question, alternative B is the best answer. Therefore, B is written in the blank in front of the number.

__B__ 1. Small and irregular shaped fields are:

A. More efficient because work in each field can be finished in a shorter period of time
B. Inefficient because maneuvering of machinery is difficult and time is lost in turning
C. More efficient because a more adequate system of roads and lanes can be used to connect the different fields
D. Inefficient because it makes it harder to set up a crop rotation program

* * * * * * * * * *

_____ 1. All of the following are major divisions of the FFA chapter program of work except:

A. Earning and saving
B. State and national activities
C. Safety
D. Public relations

_____ 2. All of the following are degrees in the FFA except:

A. American Farmer
B. Chapter Farmer
C. Greenhand
D. Star Farmer

_____ 3. Each state association may elect a certain per cent of its membership to the State Farmer Degree each year. The maximum per cent is:

A. 10%
B. 25%
C. 2%
D. 15%

_____ 4. The third line of the FFA motto is:

A. Living to serve
B. Learning to do
C. None of these
D. Doing to learn

_____ 5. The Ohio FFA Foundation, Inc., is:

A. An independent organization of businessmen
B. A means whereby interested organizations and individuals may financially assist the FFA
C. A new group to be established next year
D. Solely concerned with providing awards to FFA members

_____ 6. All are good FFA chapter officer election procedures except:

A. Vote by written ballot
B. Use a nominating committee of seniors
C. Limit officers to seniors
D. Establish a minimum scholarship requirement for potential officers

_____ 7. All of the following are aims and purposes of the FFA except:

A. To create and nurture a love of country life
B. To encourage and practice thrift
C. To encourage improvement in scholarship
D. To develop skills and abilities needed in farming

_____ 8. During the year, the minimum number of times an FFA chapter executive committee should meet is:

A. 3 times
B. Prior to each chapter meeting
C. 3 times during the year and once during the summer
D. At the call of the adviser

_____ 9. All of the following are commonly used sources of long term farm credit except:

A. Federal Land Bank
B. Commercial banks
C. Insurance companies
D. Production Credit Associations

____ 10. A group of hog producers who kept careful records averaged 5.29 pounds of feed per pound of pork produced, 7.5 pigs farrowed per litter, and 6.1 pigs weaned per litter. In terms of efficiency of production on good corn belt farms, these producers would be considered:

A. Highly efficient
B. Efficient in terms of pigs produced
C. Efficient in terms of feed conversion
D. Below average in efficiency

____ 11. A method for a farmer to lower risks would be to:

A. Concentrate on one type of livestock enterprise
B. Concentrate on one type of crop enterprise
C. Have one type of livestock enterprise and grow feed for that enterprise
D. Have supplemental livestock and crops which best fit into the major system

____ 12. When a farmer is short on capital, it is important that he:

A. Have a fast rate of turnover for his capital
B. Have his capital invested in low risk enterprises with a slow rate of turnover
C. Speculate on new crops or breeds of livestock in order to make large profits
D. Invest his money in long-time investments which are very secure

____ 13. A farmer on a small acreage can best increase his volume of business through enterprises:

A. Where labor inputs are very low in utilizing forage produced
B. Which have high labor peaks at certain seasons of the year
C. That take a medium amount of labor throughout the year
D. Which are intensive in the use of labor throughout the year

____ 14. The most suitable measuring stick for an efficient dairy enterprise would be:

A. Greatest production per animal in pounds of milk
B. Greatest production per animal in pounds of butterfat
C. Maximum profit from the enterprise
D. To have the highest quality livestock possible

____ 15. If a conservation plan is adequate the farm will:

A. Probably have higher profits the first year
B. Make more profits over the longer period of time
C. Make less profits but conserve fertility for future use
D. Show very little difference in the profits made

____ 16. Machinery should be substituted for labor when:

A. The value of labor saved is more than the increase in machine costs
B. There is a plentiful supply of labor
C. The machinery is first placed on the market
D. Farm prices are beginning to go downward

____ 17. The time for a farmer to expand production is when:

A. Industrial wages and employment rise and before his farming costs catch up
B. Industrial wages and employment have risen and farming costs have caught up and leveled off
C. General employment seems to be going into a slump
D. His costs are going up faster than prices received for his products

____ 18. When returns from capital are greater than the cost of borrowing money:

A. Profits can be increased still further by using credit
B. Profits can be maximized by using available capital and not more credit
C. It is more efficient to have enough money on hand to cover production costs
D. It is good policy to have reserve to protect credit

____ 19. Which of the following is not an advantage of specialization

A. More labor-saving equipment is practical
B. Production knowledge can be concentrated
C. Marketing and purchasing may be carried on more effectively
D. Labor can usually be distributed more evenly over the year

____ 20. Which of the following would be considered a liability for a farmer?

A. Cash on hand
B. Crops on hand to be sold
C. Bank note for operating expenses
D. Cash reserve in the bank

_____ 21. The most reliable measure of efficient economic management of a field crop is:

A. Total yield per acre
B. Plant population per acre
C. Net returns per acre
D. Value of crop sold per acre

_____ 22. The young farmer with limited cash:

A. Should invest his funds in a small farm
B. Should invest his funds in a small equity in a large farm and borrow the remainder
C. Should rent a full-sized farm and invest his funds in machinery and livestock
D. Put cash in savings account and work for wages until able to buy a farm

_____ 23. The price of any agricultural product is usually:

A. Not related to the distance from market
B. Lowest in the surplus area farthest from the market
C. Highest in the surplus area farthest from the market
D. Uniform throughout the market area

_____ 24. The individual farmer should:

A. Go in and out of an important enterprise to avoid the influence of a cycle
B. Keep rather constant acreages or number of animals
C. Increase and decrease numbers of animals when his neighbors do
D. Switch from one major enterprise to another to try to hit the best market for each

_____ 25. The firing order of a tractor is 1-3-4-2. Intake valve #1 opens after:

A. Intake valve 2
B. Intake valve 3
C. Intake valve 4
D. Can't tell from information

_____ 26. If the same numbers on the blade and tongue of the framing square are used when setting the T bevel it will give an angle of:

A. 30 degrees
B. 45 degrees
C. 60 degrees
D. 90 degrees

_____ 27. A number 4 stamped on the tang of an auger bit means it is:

A. 4 inches in length
B. 4/3 inches in diameter
C. 1/4 inches in diameter
D. 1/16 inches in diameter

_____ 28. Which of the following is not a product of the partial and complete combustion of acetylene and oxygen?

A. CO_2
B. CO
C. H_2O_2
D. H_2

_____ 29. Bronze welding is described as a process of:

A. Fusion
B. Cohesion
C. Adhesion
D. None of the above

_____ 30. Which of the following is not a layout tool?

A. Combination square
B. Level
C. Divider
D. Chamfer

_____ 31. You use a tachometer to check the cylinder speed on a combine and discover that it is too slow. To correct this trouble you would need:

A. A larger driven pulley
B. A larger driving pulley
C. A smaller driving pulley
D. None of these

_____ 32. A field is 400 feet wide and 1306.8 feet long. How many acres are in it? (1 acre = 43,560 sq. ft.)

A. 10 acres
B. 12 acres
C. 15 acres
D. 20 acres

_____ 33. Which of the following accounts for the greatest percentage of loss when combining a clean crop?

A. Shoe
B. Rack
C. Cylinder
D. Cutter bar

____ 34. The height of your eyes is 5.6 feet. Using a hand level you sight on a point 50 feet up the slope as being on the same level as your eyes. The slope of the land in front of you is:

A. 5.6 per cent
B. 11.2 per cent
C. 12.4 per cent
D. 56.0 per cent

____ 35. The main advantage of a diesel tractor compared to a gasoline tractor is:

A. More power in diesel
B. Lower initial investment
C. Lower fuel costs
D. No particular advantage

____ 36. One spark plug in an engine is not firing. Which of the following would you do to find the faulty spark plug?

A. Adjust the gap on each plug and start again
B. Clean each spark plug and replace
C. Use a wrench to short out each plug in order and listen for a change in engine operation
D. Pull out in order the spark plug lead wires at the distributor and listen for a change in engine operation

____ 37. A 5-inch V-pulley is turning at 1,750 revolutions per minute and driving a 9-inch pulley. At what rpm will the 9-inch pulley turn?

A. 176
B. 877
C. 974
D. 3,500

____ 38. The primary purpose of cultivation is to:

A. Make a mulch to conserve moisture
B. Break up clods
C. Control weeds
D. Mix fertilizer with the soil

____ 39. You have purchased a 13 x 7 drill. The width covered by the drill is:

A. 84 inches
B. 91 inches
C. 98 inches
D. 7 feet

____ 40. When planting corn you have changed from a narrow seed to a very wide seed. What adjustment must be made to correct for the width of the seed?

A. Select a seed plate with the correct length cell
B. Increase the planting-rate
C. Turn the filler ring groove up
D. Decrease the speed of forward travel

____ 41. If one bushel of wheat were spread over one acre, there would be 18 to 20 kernels per square foot. A combine operating in wheat is found to leave 40 kernels per square foot. What is the loss in bushels per acre?

A. 1 bu.
B. 2 bu.
C. 4 bu.
D. 8 bu.

____ 42. You find a large amount of shelled corn on the ground behind a corn picker. Which of the following adjustments would help correct this condition?

A. Increase rate of forward travel
B. Move snapping rolls closer together
C. Decrease the tension on the husking rolls
D. Add lugs to the snapping rolls

____ 43. Where should the footing of a house be placed?

A. On top of the ground
B. Just below the top soil
C. Where the footing is placed makes very little difference
D. On firm soil below frost level

____ 44. A mixture of concrete is too sloppy or wet for placing in a form. Which item listed below should be performed to make a stiffer mix and yet not change the strength?

A. Add more cement and gravel
B. Add more cement
C. Lt it set a while before placing it in the form
D. Add more cement, gravel and sand as in original proportion

____ 45. A bin on the second floor of a barn is 8 feet square and 6 feet high. One cubic foot of the bin holds (.8) or four-fifths of a bushel. The bid is filled with wheat which weighs 60 pounds per bushel. How much weight is there on each square foot of the bin floor?

A. 288 lbs.
B. 384 lbs.
C. 480 lbs.
D. 2880 lbs.

____ 46. The voltage of a circuit supplying a particular electric heating load is doubled, but the wattage of the load is kept constant. Power (watts) loss due to resistance in the circuit conductors will be:

A. Reduced to one-half its former value
B. Increased to double its former value
C. Increased to four times its former value
D. Reduced to one-fourth its former value

____ 47. An electric hot water heater rated 5290 watts at 230 volts is mistakenly connected to 115 volt service. The resistance of the heater is now approximately:

A. 5 ohms
B. 10 ohms
C. 20 ohms
D. 25 ohms

____ 48. 2000 watt hours is equivalent to:

A. 200 kilowatts consumed for a period of 6 minutes
B. 1 kilowatt consumed for a period of 30 minutes
C. 2 kilowatt hours consumed over a period of 30 minutes
D. 20 kilowatts consumed over a period of 10 minutes

____ 49. All of the following are items of fixed cost in owning a farm tractor except:

A. Interest on investment
B. Insurance
C. Taxes
D. Labor

____ 50. If a tractor is operated 800 hours per year instead of 400 hours per year, all of the following statements could be expected to be true except:

A. The total cost of operation per hour would increase
B. The total cost of operation would increase
C. The fixed costs per hour would be reduced
D. The depreciation cost per hour would be lower

____ 51. The machines which a farmer can best afford to own are those:

A. Which are used most throughout the year and are efficient labor savers
B. Used only at peak season work loads and are available with custom operators
C. Which are high investments and used only during a short period of time
D. Which are older and cheaper to purchase although newer models may be more efficient

_____ 52. The cost of owning machinery, for a farmer who is limited in the amount of capital which he has for production purposes, can be determined by:

A. The rate he could earn on an outside loan or investment
B. The rate of return his money would yield when used for other investments on the farm
C. The rate of interest he would get if he put the money in a savings account
D. The rate of return he would get if the amount were invested in low risk investments such as government bonds

_____ 53. The number of bd. ft. in 16 pieces of 2" x 6" x 14' oak is:

A. 224 bd. ft.
B. 448 bd. ft.
C. 112 bd. ft.
D. 672 bd. ft.

_____ 54. Scaly and ulcerated skin, diarrhea and lameness are common visible symptoms in swine of:

A. Hog Mange
B. Rickets
C. Vitamin B_2 deficiency (Riboflavin)
D. Hog Flu

_____ 55. Hog cholera is:

A. A highly contagious disease
B. A non-contagious disease
C. A rare disease among swine
D. Usually non-fatal to swine

_____ 56. When a cow ovulates, the ova is:

A. Being fertilized
B. Being released
C. Undergoing reduction division
D. Being imbedded

_____ 57. When would be the best time to breed a cow?

A. When you first notice her in estrus
B. When she is no longer mounting
C. 12 hours after you first notice her in estrus
D. For all freshening

_____58. Fertilization takes place when:

A. A bull serves a cow
B. A cow comes in estrus
C. The egg and sperm unite
D. The calf is born

_____59. All of the following are advantages of artificial breeding of dairy cattle except:

A. The danger of cross bulls is eliminated
B. The cash cost per service is lower
C. The total cost per service is lower
D. The danger of transmitting disease is lessened

_____60. Incomplete deminance in color means that when a red cow is crossed with a white bull, the off-spring will all be:

A. Red
B. White
C. Roan
D. Born dead

_____61. The practice of mating closely related animals is called:

A. Outcrossing
B. Inbreeding
C. Nicking
D. Artificial breeding

_____62. The dressing percentage for choice steers is ordinarily:

A. 52%
B. 60%
C. 68%
D. 80%

_____63. All of the following are protein supplements for beef cattle except:

A. Cottonseed cake
B. Linseed oil meal
C. Soybean oil meal
D. Molasses

_____64. All of the following terms describe corn as a feed for beef cattle except:

A. Palatable
B. High in Vitamin A
C. Low in total digestible nutrients
D. Low in fiber

____ 65. The dressing percentage of beef cattle is most affected by:

A. Differences in sex
B. Differences between pregnant and open heifers
C. Differences in finish
D. Differences between breeds

____ 66. Pelleting feeds for fattening beef cattle has all the advantages listed below except:

A. Less feed wasted
B. Less feed required per pound of gain
C. Faster gains
D. Lower cost per pound of gain

____ 67. The gestation period for swine is:

A. 124 days
B. 3 months and 3 days
C. 104 days
D. 3 months, 3 weeks, and 3 days

____ 68. The best source of calcium for feeding brood sows is from:

A. Corn
B. Iodized salt
C. Soybean oil meal
D. Ground limestone

____ 69. The most critical time in feeding bred gilts or sows during gestation is:

A. The last month
B. The first month
C. Two weeks after the pigs are born
D. During the flushing period

____ 70. Pigs farrowed by gilts which have received aureomycin are usually:

A. Larger at birth
B. Stronger at birth
C. Stronger and more uniform at weaning time
D. All of the above

____ 71. Milk should be cooled quickly to a temperature of:

A. 26° F.
B. 32° F.
C. 45° F.
D. 60° F.

____ 72. Name the disease of dairy cows that most commonly affects the quality of milk:

A. Mastitis
B. Pink eye
C. Cholera
D. Ketosis

____ 73. To control feed flavor in milk, silage should be fed:

A. Immediately before milking
B. During milking
C. After milking
D. 3 hours before milking

____ 74. The bacterial plate count of milk for fluid consumption as it is delivered from the farm shall not exceed:

A. 10,000
B. 50,000
C. 200,000
D. 500,000 bacteria per milliliter

____ 75. Antibiotics most likely to contaminate milk are those administered to the cow:

A. By drenches through the mouth
B. Through salves on the surface of the teats
C. Through injections in the skin
D. Through materials injected into the teats

____ 76. The major function of pasteurization of milk is to:

A. Kill bacteria
B. Increase palatability
C. Remove foreign matter
D. Reduce the size of the fat globules

____ 77. Dairymen are encouraged to pasteurize milk for home consumption because:

A. The heat dissolves foreign material making the milk richer
B. The heat destroys harmful microorganisms which may be present, making the milk safe for consumption
C. Raw milk doesn't taste as good as pasteurized milk
D. It improves the nutritional value of the milk

_____ 78. For a farmer just getting started in farming, to raise purebred stock for show purposes:

A. Is a business with very little risk involved
B. Is easy to get into and takes very little capital
C. Requires large capital funds and involves large risks
D. Will give him quick returns for the capital which he has invested

_____ 79. The units of heredity which are responsible for expressing a single characteristic are called:

A. Chromosomes
B. Genotypes
C. Phenotypes
D. Genes

_____ 80. Sand soil particles are smaller than:

A. Silt
B. Clay
C. Gravel
D. All answers correct

_____ 81. Corn should be planted:

A. As deep as possible to get roots down to water (about 3-4 inches)
B. As shallow as possible to get seed in warm soil (about 1/2-1 inch)
C. Deep enough for moisture, yet shallow enough to be in the upper strata of warm soil ($1\frac{1}{2}$-3 inches)
D. As shallow as possible to avoid insect damage (1/2-1 inch)

_____ 82. The earliest date that corn may be safely planted is determined primarily by:

A. Soil moisture
B. Soil temperature
C. The length of day
D. Farm work load

_____ 83. The soil temperature is best for planting when it reaches:

A. 54 degrees
B. 60 degrees
C. 75 degrees
D. 81 degrees

_____ 84. Planting more than three inches deep:

A. May kill the sprout because it is too difficult to reach the surface
B. May place the seed in too much moisture for germination
C. Place the seed too far from the fertilizer
D. Results in greatly increased supply of phosphorous for plant

_____ 85. Planting too shallow is harmful because:

A. The seedling may lack moisture for germination
B. The plant will suffer from drought in July
C. Moles may damage the grain
D. Late cold spells may stop germination

_____ 86. With heavier plant population should go:

A. A high fertility level
B. A smaller type corn plant
C. An early maturing hybrid
D. A mid-season hybrid strain

_____ 87. A good ear size to strive for is:

A. .25 to .50# ear
B. .50 to .75# ear
C. .75 to 1.00# ear
D. 1.00 to 1.50# ear

_____ 88. All of the following are important in deciding the most profitable rate of fertilizing corn except:

A. The price of corn
B. The expected yields from different amounts of fertilizer
C. The color of the soil
D. The cost of the fertilizer

_____ 89. A land use capability map includes all of the following information on each land area except:

A. Slope
B. Degree of past erosion
C. Dominant soil series
D. Per cent of run-off

_____ 90. Fertilizer should be used as long as:

A. It increases the crop yields
B. The added returns are more than the expenses over a reasonable length of time
C. The quality of the crop is increased
D. The original fertility of the soil is maintained

_____ 91. Nitrogen fixing bacteria are found in the soybean plant in the:

A. Leaf petioles
B. Stalks
C. Blossoms
D. Root nodules

_____ 92. The most important ingredient in an inoculant used on soybeans is:

A. Bacteria
B. Fertilizer
C. Mineral
D. None of these

_____ 93. Which of the following groups of inoculant can be used to inoculate soybeans?

A. Clover group
B. Bean group
C. Pea and vetch group
D. None of these

_____ 94. One bushel of soybeans will produce about how many pounds of soybean oil meal?

A. 30
B. 36
C. 42
D. 48

_____ 95. Chemical defoliation of soybeans is most important when:

A. An early frost has occurred
B. September and October are warm and wet
C. Short season varieties are used
D. Corn is to follow soybeans in the rotation

_____ 96. What is the highest moisture content at which you should try to store soybeans at home without a drier?

A. 9%
B. 11%
C. 13%
D. 15%

_____ 97. What is the minimum per cent germination necessary for seed to be certified?

A. 70%
B. 90%
C. 99%
D. 80%

____ 98. Companion crops (such as oats and wheat) are often used by farmers to obtain a return while the slower developing seeding (alfalfa-brome) is becoming established. This procedure has resulted in poor stands of meadow. The basic reason for this is from competition between the companion crop and seeding for:

A. Lime
B. Inoculation
C. Light
D. Weeds

____ 99. Which is the most economical fertilizer in terms of cost per pound of plant food?

A. 2-12-12 @ 50.00 per ton
B. 5-10-10 @ 55.00 per ton
C. 8-16-16 @ 60.00 per ton
D. 12-12-12 @ 72.00 per ton

____ 100. The best control for loose smut of wheat is:

A. Crop rotations
B. Seed treatment of Ceresan M
C. Resistant varieties
D. Control of barberry (alternate host)

APPENDIX B

Department of Agricultural Education
The Ohio State University
and
Vocational Agriculture Service
State Department of Education

BIOLOGICAL SCIENCE--AGRICULTURE TEST

by
S. S. Sutherland
University of California, Davis, 1961

DIRECTIONS

This is a test of your knowledge of biology as applied to agriculture. For most questions there are five possible answers. You are to decide which is the best one. You should answer all questions even when you are not perfectly sure that your answer is correct. You may guess, but you should avoid wild guessing. Do not spend too much time on any one question.

Study the sample questions below, and notice how the answers are to be marked on the separate answer sheet.

Sample 1. Which of the following is the name of a breed of cattle:

A. Poland China
B. Percheron
C. Southdown
D. Hereford
E. Leghorn

For Sample 1 the correct answer, of course, is D (Hereford). In the five answer spaces after Sample 1 on your answer sheet, an "X" has been made through the letter D.

Sample 2. The name given to the scientific study of living things is--

A. Chemistry
B. Physics
C. Biology
D. Geology
E. Anthropology

The correct answer for Sample 2 is "Biology" which is answer C; so you would answer Sample 2 by making an "X" through C on your answer sheet. Do this now.

Read each question carefully and decide which one of the answers is best. Notice what letter your choice is. Then on the separate answer sheet, make an X through the letter. In marking your answers, always be sure that the question number in the test booklet is the same as the question number on the answer sheet. Erase completely any answer you wish to change, and be careful not to make stray marks of any kind on your answer sheet or on your test booklet. When you finish a page go on to the next page. If you finish the entire test before the time is up go back and check your answers. Work as rapidly and as accurately as you can.

When you are told to do so, open your booklet to page 2 and begin. The working time for this test is 60 minutes.

1. The difference between living and non-living things is best described by one of the following statements--

A. Only living things grow or change in size
B. Non-living things do not grow or move about
C. Living things can reproduce their own kind
D. Non-living things can become living things if they produce growth
E. There is no such thing as non-living matter

2. The science that deals with classification and naming of organisms is called--

A. Botany
B. Psychology
C. Taxonomy
D. Physiology
E. Zoology

3. Latin names are assigned to plants and animals--

A. To make it difficult for people not trained in scientific work to understand
B. To help keep Latin a "live" language
C. Because all early work was done in Latin and it is too late to change now
D. To make one name universal for the same organism
E. Because there are more descriptive words to use in Latin

4. The scientific name of barley is Hordeum vulgare. These two Latin words tell--

A. The family and the order
B. The order and the class
C. The genus and the species
D. The phylum and the kingdom
E. The phylum and the class

5. Which one of the following does not belong in the following order?

A. Deer
B. Bison
C. Horse
D. Bear
E. Zebra

- -

6. The interrelationship between living organisms and their environment is called--

   A. Botany
   B. Zoology
   C. Taxonomy
   D. Ecology
   E. Physiology

7. One of the following would not change the environment of plants--

   A. Wind
   B. Heat
   C. Water
   D. Gravity
   E. Light

8. Plants compete for all but one of the following--

   A. Heat
   B. Light
   C. Oxygen
   D. Carbon dioxide
   E. Nutrients

9. In a changing environment, living organisms can survive only through adaptation and/or migration. One of the following is not related to the above principle--

   A. Migration
   B. Estivation
   C. Hibernation
   D. Winter sleep
   E. Solar rotation

10. The coyote, which is classified as a carnivore, has done considerable damage to the sheep and cattle industry throughout the U.S. He has an appetite for young lamb and calves, although he also eats a variety of other animals. His ultimate source of energy and food can be traced to--

    A. Plants
    B. Insects
    C. Lizards
    D. Rodents
    E. Jackrabbits

11. The U. S. Department of Agriculture has many restrictions on the importation of plants and animals into the United States from foreign lands, especially if the organism does not already exist in the United States. The reason for this is--

    A. The organism may not be suited to our climate
    B. The country of origin does not have the same political views as the U.S.

C. The organism may adapt so well it may become a pest
D. Competition may be so keen for the organism that it will not survive
E. The S.P.C.A. has gone on record opposing the import of foreign organisms

12. Living things can survive in a changing environment only through adaptation or migration. In which type of farming does the farmer do the most toward changing the environment of the crop or livestock he produces?

A. Range beef cattle
B. Growing dry land barley
C. Producing apricots on irrigated land
D. Producing grade A milk
E. Growing ornamentals in a greenhouse

13. Which of the following "Rules of Thumb" are not based directly upon the principle that plants and animals survive only by adapting to their environment or by migrating?

A. Warm season crops tend to have deeper roots than cool season crops
B. All biennial plants require long days and low temperature for optimum flowering
C. Annual plants endure unfavorable environmental conditions through seed dormancy
D. Where tomatoes produce maximum yields, potatoes produce minimum yields
E. Wind machines and orchard heaters should be used in many areas to reduce the danger of frost damage

14. The success of a farmer is directly dependent upon his ability to adjust the plants and animals he grows to their environment or to adjust the environment to his livestock and crops. Which of the following does not illustrate adapting plants or animals to their environment?

A. Dehorning cattle
B. Pruning fruit trees
C. Irrigating barley
D. Scarifying legume seed
E. Castrating pigs

15. All living organisms affect each other in some manner. Which of the following best illustrates a detrimental relationship in which one or both of the organisms suffer?

A. Cattle and other ruminants have microbes in their digestive systems which affect digestion
B. Nematodes in a soil on which sugar beets are grown
C. A number of cattle fattening in a feed lot
D. Grapefruit trees grown in a date garden
E. Nitrogen-fixing bacteria in soil where alfalfa is grown

16. Sometimes two organisms live in a close relationship which is beneficial to both of them. Such a situation is called--

A. Symbiosis
B. Adaptation
C. Parasitism
D. Autecology
E. Synecology

- -

17. The movement of materials from an area of high concentration to one of low concentration is called--

A. Circulation
B. Diffusion
C. Mixing
D. Percolation
E. Evaporation

18. All living organisms depend upon the fact that, in general, materials tend to move from an area of high concentration to an area of low concentration. Which one of the following is not an application of this principle?

A. Some plants will not grow in an alkali soil
B. Fresh water is sprinkled over vegetables in the grocery store to keep them crisp
C. Alkaline soils may be improved by leaching
D. Too heavy applications of fertilizer may kill a plant
E. Celery is blanched by excluding light from the lower stalks of the plant

19. The over-application of fertilizer will produce symptoms in the plants called fertilizer burns. This condition is brought about by the change in--

A. Nutrient requirement
B. Moisture requirement
C. Respiration requirement
D. Photosynthesis requirement
E. Osmotic relationship

- -

20. The manufacture of simple sugar by green plants is accomplished by a process called--

A. Chlorophyll
B. Transpiration
C. Respiration
D. Photosynthesis
E. Food production

21. Green plants are capable of manufacturing their own food when light and essential elements are present because they contain--

A. Nucleolus
B. Cytoplasm
C. Protoplasm
D. Vacuoles
E. Chlorophyll

---

22. Which one of the following is not directly accomplished by the presence of organic matter in the soil?

A. Decreases water run-off
B. Increases water holding capacity
C. Improves aeration of soil
D. Increases available plant food
E. Produces a better soil structure

23. All plant and animal life is dependent upon cycles in which certain essential food elements are kept in constant circulation between plants, animals, soil, air and water. Which one is not an example of this cycle?

A. Gypsum added to the soil to improve its structure
B. The Pilgrims burying a fish beside each hill of corn planted
C. The making and using of a compost heap
D. The use of manure as a fertilizer
E. Plowing under clover or alfalfa

24. When barley is planted on ground which grew barley the year before, there will be streaks across the field where the plants are lighter in color and rather yellowish. These lighter colored strips are where straw was left by the harvester when the preceding year's crop was harvested. The reason for this is--

A. Lack of moisture, since the straw kept the rain off these strips of soil
B. The straw kept the temperature of the soil too low during the summer
C. Insufficient nitrogen in the soil to support both the barley and the soil bacteria which break down and decompose the straw
D. Too much nitrogen in the soil so that the soil bacteria do not need to break down the straw to obtain nourishment
E. The straw smothered out the new barley plants and prevented them from growing as rapidly as where the ground was bare

---

25. The growth of an animal is influenced by all but one of the following--

A. Age of the organism
B. Health
C. Heredity
D. Color of the organism
E. Temperature

26. Grasses will recover after grazing or cutting because their growing points (meristematic tissue) are located in the--

A. Margins of the leaves
B. Tips of the leaves
C. Bases of the leaves
D. Roots
E. Tendrils

27. A farmer, fencing his pasture, has used a 15 foot tree as a post and nailed his woven wire fencing to this tree. The top of his fence is 4 feet high and the bottom is 6 inches above the ground. The following year he discovers his sheep are getting out and immediately remembers his live post. The farmer returns and finds to his amazement that the tree is now 20 feet tall and the bottom of his fence is now--

A. About 1/2 foot above the ground
B. About 1 foot above the ground
C. About 5 1/2 feet above the ground
D. About 3 1/2 feet above the ground
E. About 4 feet above the ground

- -

28. All living things require specialized chemical substances to regulate the life processes necessary for growth and development. All but one of the following practices are applications of this principle--

A. Pruning roots when transplanting
B. Defoliating cotton by spraying with synthetic auxins
C. Pruning fruit trees
D. Harvesting barley
E. Thinning fruit by use of synthetic auxin to cause abscission

29. Synthetic growth regulators are used for all but one of the following--

A. Killing dandelions
B. Shortening dormancy of fruit trees
C. Rooting cuttings
D. Prevening fruit drop
E. Formation of fruit buds

30. "Heading back" trees by pruning the ends of branches promotes growth of new shoots because--

A. More sunlight is admitted to the other branches
B. Materials in the tips of the branches which prevent or slow down growth are removed
C. There is more plant food available to the parts of the tree which remain
D. Less moisture is lost from the leaves

- -

31. Diseases or malfunctions that may occur on plants or animals are serious because they--

A. Generally affect some physiological process
B. Make the organism sick
C. Can ruin the appearance of the plant or animal
D. May affect humans if not controlled
E. Are infectious

32. Non-infectious diseases in animals may be caused by all but one of these--

A. Smog
B. Improper feeding
C. Viruses
D. Heredity
E. Poisons

33. Infectious diseases in plants are controlled by all but one of these--

A. Breeding disease resistant plants
B. Using sprays and dusts
C. Seed treatment
D. Injection of vaccines
E. Changing cultural practices

34. All living organisms have parasites which are capable of affecting their life processes to a degree which depends upon the susceptibility of the host, the environment, and the nature of the parasite. Which of the following is not an application of this principle?

A. Pigs in certain areas are born hairless and have goiters
B. Cattle grubs cause an estimated loss of 100 million dollars annually
C. Reduction of aphid damage to alfalfa has been obtained by introducing a fungus which attacks the aphids
D. Lice and mites on chickens may reduce egg production
E. The "lady bug" or Australian lady beetle feeds upon and is used in the control of cottony cushion scale

35. In order to survive, living things possess the ability to perpetuate their own kind from a part of themselves. All but one of the following terms are related to this statement--

A. Asexual reproduction
B. Sexual reproduction
C. Alternation of generations
D. Crop rotation
E. Fission

36. Fruit trees are usually propagated asexually by cuttings or by grafting and budding because--

A. They do not produce viable seeds
B. The seed produced by fruit trees is usually not true to variety
C. It is easier and quicker
D. It is cheaper
E. It is too difficult to harvest and store the seeds

37. Our domestic animals reproduce sexually because--

A. They are one of the lower forms of life
B. They are one of the higher forms of life
C. They have been domesticated
D. Sexual reproduction is a less complicated process
E. All forms of animal life reproduce only in this way

38. Which of the following normally reproduce both sexually and asexually?

A. Corn
B. Johnson grass (Bermuda grass)
C. Swine
D. Barley
E. Sunflowers

- -

39. All living organisms respond in some fashion to stimuli. One of the following would not necessarily stimulate an organism--

A. Soil type
B. Light
C. Heat
D. Cold
E. Darkness

40. Beehives are placed in alfalfa fields which are grown to produce seed because the alfalfa flower reacts to a bee entering the flower by releasing pollen, thereby making a larger yield of seed possible. This is an example of--

A. Photosynthesis
B. Diffusion
C. Irritability
D. Pathology
E. Transpiration

- -

41. Which one of the following conditions is essential to the germination of seeds?

A. The seeds have gone through a period of dormancy
B. The seeds have been treated for fungus diseases
C. The soil in which the seed is planted is free from weeds
D. The soil in which the seed is planted is fertile
E. The seed is planted in the "dark of the moon"

42. Which one of the following environmental factors does not affect the germination of seeds?

A. Moisture
B. Temperature
C. Type of soil
D. Oxygen
E. Light

- -

43. A plant will attain optimum growth, provided other environmental factors are favorable, when all essential nutrients for growth are available--

A. In adequate amounts
B. In much more than adequate amounts
C. In much less than adequate amounts
D. In slightly less than adequate amounts
E. But some in adequate amounts and others in inadequate amounts

44. In fertilizing plants, which of the following is unimportant?

A. The time of day when the fertilizer is applied
B. The location of the fertilizer with respect to the plant
C. The nutrients contained in the fertilizer
D. The pH of the soil
E. The method of applying the fertilizer

45. The letters "C HOPKNS Cafe Mg Cu Zn Mo Cl"--

A. Are a code used by the fertilizer dealers
B. Are the symbols for all of the nutrients essential for plant growth
C. Are the symbols for the micronutrients needed by plants
D. Is the trade name for a commercial fertilizer

46. Plants require certain available essential nutrients to attain maximum growth, if all other factors are favorable. Which group of minerals or elements are all essential nutrients?

A. Nitrogen, hydrogen, oxygen, sulfur, humus
B. Phisphorus, potassium, sulfur, calcium, uranium
C. Magnesium, carbon, iron, zinc, lead
D. Nitrogen, carbon, iron, zinc, oxygen
E. Nitrogen, carbon, potassium, lead, magnesium

- -

47. All plants transpire. Whenever the uptake of water by the roots is lower than the rate of transpiration, wilting will be initiated and the severity of damage, if any, will be dependent upon the kind of plant, the stage of growth, and the duration of time that the condition exists. Transpiration means--

A. The loss of water vapor by the aerial portion of the plant to the atmosphere
B. A distension or pressure created by the protoplasm against the cell wall caused by the accumulation of fluids
C. The time at which the available soil moisture is less than what is required by the plant
D. Difference in atmospheric pressure
E. The amount of water a soil will hold against gravity when allowed to drain freely

48. In the same environment, which plant will transpire most rapidly?

A. Cactus
B. Sunflower
C. Bamboo
D. Pine tree
E. Apricot tree

49. Which of the following does not influence the rate of transpiration in plants?

A. Temperature
B. Humidity
C. Wind velocity
D. Availability of nutrients
E. Size and shape of leaves (number of stomata)

50. When transplanting crop plants it is important to remember that there will be some wilting by transpiration losses. This deficit can best be controlled at planting time by--

A. Reducing the root area
B. Good soil moisture
C. Reducing the leaf area
D. Irrigating after planting
E. Irrigating before planting

- -

51. All organisms depend in varying degrees on a system by which nutrients, oxygen, and regulatory secretions are distributed in the organisms, and the waste products of metabolism are removed. This indicates that plants and animals--

A. Are related
B. Have similar organs
C. Transport food in a fluid
D. Have hearts to pump these secretions
E. Have "blood"

52. Which of the following is not a part of the circulatory system in higher animals, such as farm animals?

A. Intestines
B. Heart
C. Veins
D. Capillaries
E. Arteries

53. In the circulatory system of plants the xylem and phloem correspond to which parts of the circulatory system in animals?

A. Heart and blood
B. Capillaries and blood
C. Veins and arteries
D. Blood and arteries
E. Lungs and heart

54. The benefit which livestock derive from their food depends upon the composition of the food, its nutritive value and the ability of the animal to utilize the food. Which of the following is not based upon this principle?

A. The nutritional content of a feed increases with an increase in the % of dry matter
B. The higher the % of lignin in a feed, the lower its digestibility
C. The higher the % of protein in a feed, the lower its nutritional value
D. It takes more pounds of roughage than of concentrates to produce the same amount of nutrients
E. As a feed crop matures the % of moisture and protein decreases

55. Which of the following best defines a balanced ration?

A. It is always palatable
B. It needs no further adjustment
C. It is available and economically practical
D. It supplies all the essential nutrients in the right amounts and proportions for a twenty-four hour period
E. It supplies all the essential nutrients in the right amounts and proportions for a month

56. The type of nutrient which is highest in energy value is--

A. Protein
B. Carbohydrates
C. Minerals
D. Fats
E. Lignin

57. Which of the following is not a good "rule of thumb" for the feeding of arm animals?

A. As an animal matures, the required protein decreases; the required carbohydrate increases
B. The feed requirement for the maintenance of an animal depends upon the size of the animal, its activity, and its environment
C. Approximately three-fourths of the feed eaten by an average dairy cow is used for milk production

- -

58. Animals perceive changes in their environment by way of their nervous systems. Which of the following is not an application of this principle?

A. Strangers present in a barn at milking time may cause dairy cattle to hold up milk
B. A period of extremely hot weather may cut down egg production of a poultry flock
C. A nervous herdsman may make cattle nervous
D. Cattle coming in contact with an electric fence and receiving a shock will avoid it in the future
E. The appearance of a healthy animal is quite different from that of a diseased animal

59. The endocrine glands regulate or control four of the following life processes of animals. Which one is not directly regulated by these glands?

A. Rate of metabolism
B. Amount of blood sugar
C. Blood pressure
D. Activity of ovaries or testes
E. Digestion

60. The livestock breeder is most concerned with the function of which one of the following endocrine glands in his animals?

A. Gonads
B. Thyroid
C. Parathyroid
D. Pancreas
E. Adrenal

- -

61. All organisms derive the energy required for the activities from the oxidation of simple foods within their protoplasm. The rate of energy release is dependent upon those internal and external factors which create the need for energy. This being a true principle, all organisms--

A. Respire
B. Breathe
C. Transpire
D. Inhale
E. Exhale

62. The rate at which energy is released as plants and animals respire is dependent upon factors which create the need for energy. Which of the following is not an agricultural application of this principle?

- A. The respiration rate of a vegetable determines the length of time which it can be stored
- B. Livestock being fattened should be kept quiet
- C. Compacted soil hinders growth of plants
- D. Livestock should be protected from extreme cold
- E. Salt is used in preserving ham

63. Chemically, the process if respiration is--

- A. The same as photosynthesis
- B. The reverse of photosynthesis
- C. The same as transpiration
- D. The reverse of transpiration

- -

64. The branch of biology dealing with the study of heredity is called--

- A. Geriatrics
- B. Genetics
- C. Physiology
- D. Ecology
- E. Taxonomy

65. On the basis of the genes which they possess, which of the following cattle would be most closely related?

- A. Sire and daughter
- B. Identical twin calves
- C. Dam and daughter
- D. Dam and sire
- E. A bull calf and a heifer calf not twins

66. A farmer has a valuable and highly productive cow which lost the sight of one eye as a result of an accident.

- A. It is all right to continue raising calves from her
- B. The unsoundness is likely to be transmitted to her offspring
- C. The calves will probably have a tendency to have weak eyes
- D. There will be a tendency toward moonblindness in the offspring
- E. It is impossible to tell ahead of time what would be the effect on the offspring

In the crossing of breeds of cattle the traits for some characteristics are dominant and some are recessive. In the following crosses of Aberdeen Angus and white Shorthorns the black color of the Angus is dominant over white and the polled characteristic of this breed is dominant over horns of the Shorthorns.

Let B stand for Black color
b stand for White color
P stand for polled
p stand for horned

Listed below are 5 possible crosses that involve the listed traits. For each question 67 to 75 determine which cross in the Key applies. Then mark on your answer sheet for each question the letter that is the same letter as that cross.

A. BBPP x BBPP
B. BbPp x BbPp
C. bbpp x bbpp
D. bbPP x bbPP
E. BBpp x BBpp

67. Which cross would give you only pure white horned calves?

68. Which cross would give only pure black polled claves?

69. Which cross would give only pure white polled calves?

70. Which cross would give a ratio of three black polled calves and one white horned calf

71. Which cross would be used if you were interested in breeding for the dominant traits?

72. Which cross would be used if you were interested in only the recessive traits?

73. Which cross would be used if you wanted dominant color and recessive horned characteristics?

74. Which cross would give only recessive color and dominant polled characteristics?

75. Which cross would produce the genotype bbPP?

# # # # # # #

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